A Case Study of Successful Performance of Retrofitted Masonry Substations

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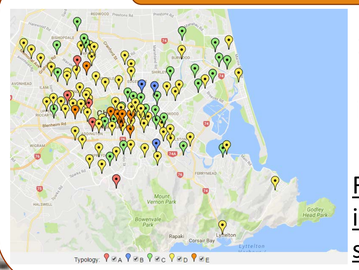
Background

- Since the mid 1990s, the Christchurch inventory of substation buildings was seismically retrofitted as part of the Risk and Realities improvement programme.
- The substation buildings were retrofitted using a system of simple and cost-effective steel elements.
- The 2010/2011 Canterbury earthquakes caused significant immediate disruption to power distribution network in Christchurch.
- It took a single day in September 2010 and ten days in February 2011 to restore power to 90% customers.

Objective

To study the seismic performance of masonry substation buildings from a multi-disciplinary perspective on structural, economic and social aspects.

Location



114 substation buildings were investigated

Fig. 1. Location of investigated substation buildings

Economical

- Building strengthening expenditure = $NZD6 million
- Save in direct asset replacement cost = $NZD60 - $NZD70 million (Orion NZ Ltd, 2012)

Architectural heritage

Listed in the City Plan as Group 4 heritage buildings due to the decorative styles. (Hartrick, 2003)

Temple of Electricity

Neo – Georgian pavilion

Art Deco Moderne

Fig. 3. Three main decorative styles of 1920s to 1930s construction

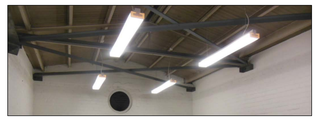
Seismic retrofitting

Walls

Diagonal and vertical steel bracing members

Epoxied steel dowels

Roof



Steel bracing of roof diaphragm

Installed steel plate on perimeter beam at eaves level

Fig. 4. Seismic strengthening details

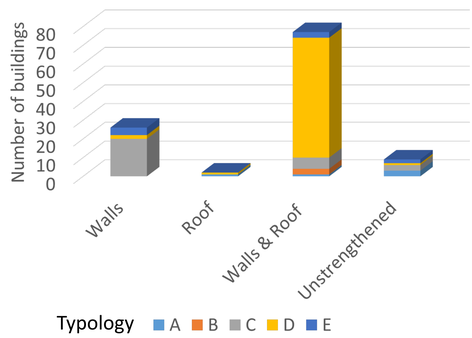
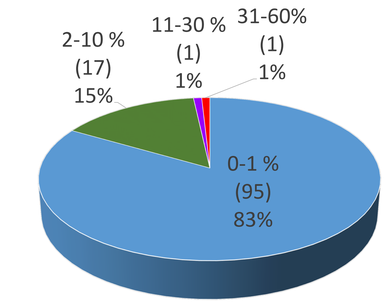


Fig. 5. Strengthened building components

Post-earthquake assessment



Level of damage	Description
0-1 %	Insignificant
2 – 10 %	Moderate
11 – 30 %	Significant
31 – 60 %	Heavy

Fig. 6. Building damage levels

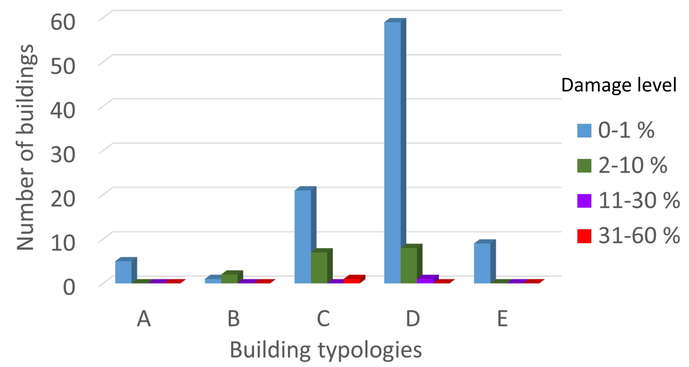


Fig. 7. Distribution of damage levels

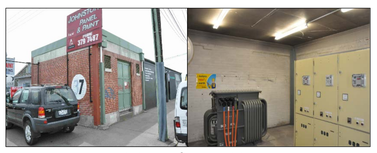
Building characteristics

Typology A

Typology B

Typology C

Typology D



Typology E

Fig. 2. Building typologies

Table 1. Description of building typologies

Typology	Masonry Type	Building continuity	Footprint	Parapet	Roof diaphragm	No. of buildings
A	Infill masonry	Isolated	Rectangular	No	Rigid	5
B	URM	Isolated	Octagon	Yes	Flexible	3
C	URM	Isolated	Rectangular	Yes/No	Rigid	29
D	URM	Isolated	Rectangular	Yes/No	Flexible	68
E	URM	Row	Rectangular	Yes/No	Rigid/Flexible	9

Conclusions

- 83% of the substation buildings survived with minor damage and 15% survived with moderate damage while only two substation buildings experienced significant and heavy damage.
- Cost savings were approximately up to $NZD70 million.
- Because many historical buildings were demolished after the 2010/2011 Canterbury earthquakes, these substations have increased heritage importance within the community.

References

Hartrick, E. (2003). The architectural heritage of Christchurch 10, Pavilions, temples & four square walls : Christchurch pump houses and substations. Retrieved from http://christchurchcitylibraries.com/Heritage/Publications/ChristchurchCityCouncil/ArchitecturalHeritage/PavilionsTemplesFourSquareWalls/1877313092.pdf

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